REMARKS

Claims 1 through 36 were pending in this application. Applicant has herein amended claims 1, 2, 15, and 25. Accordingly, claims 1-36 remain pending.

The Present Invention

The present invention relates to microstrip antennas with improved low angle performance while not diminishing performance closer to the zenith. Particularly, the present invention improves low angle gain of a microstrip antenna primarily by two features of the design. The first feature is a dielectric lens that entirely encapsulates the patch and refracts electromagnetic waves so as to increase the gain at low angles while not substantially affecting gain at higher angles. The second feature is placing the patch on a second ground plane raised above a first ground plane. The raised, second ground plane further enhances the refraction effect, thereby increasing radiation gain at low angles without diminishing gain at the zenith.

The Rejections Under 35 U.S.C. § 112

In Section 1 of the Office Action, the Office objected to the disclosure for several reasons. First, the Office stated that it is not understood what is meant by "the gain of 0 Dai" on page 10, line 13. Applicant has herein corrected a typographical error to replace "Dai" with "dB."

The Office also asserted that the term "low angles" has different definitions in the specifications and requested that the specification be amended to provide a more explicit definition. In the amendments to the claims, Applicant has eliminated any use of the term "low angles." Accordingly, this issue is now moot.

In Section 2 of the Office Action, the Office objected to the specification as failing to provide proper antecedent basis for the claimed subject matter insofar as the phrase "as low as 35° to said patch" does not appear in the originally filed disclosure. Applicant has amended claims 1 and 15 to eliminate the use of that phrase. Accordingly, this rejection is now moot. However, in any event, there is no requirement in the law that a patent specification contain literally identical language in order to support a claim recitation. Figures 5A, 5B, 6A and 6C are radiation graphs comparing an antenna without a lens to the same antenna with a lens in

accordance with the present invention. These graphs show an increase in gain of about at least 0.5dB at 35°, thus providing all the support necessary for such a claim recitation.

In Section 3 of the Office Action, the Office rejected claims 2-7, 12, 13, 16-22, 25-28, 31 and 36 under 35 U.S.C. § 112, second paragraph, as indefinite. Particularly, with respect to claims 2 and 16, the Office asserted that the phrase "the low angles" lacks the proper antecedent basis because the term was deleted in claims 1 and 15 and there is confusion regarding the definition of "low angles," as pointed out earlier in the Office Action. Applicant has herein amended the claims to eliminate the use of this phrase and, therefore, has made this rejection moot.

With respect to claim 25, the Office asserted that it is redundant because it is identical to claim 24 and asks whether it should depend from another claim. The Office's point is well taken. Claim 25 should depend from claim 15 and has been amended accordingly herein.

The Office asserted that claims 26 and 31 are not understood because the 35° angle is established in independent claims 1 and 15, and the antecedent basis for "said radiation gain" for these dependent claims is established at 35° in claims 15 and 31. The Office asserted that it is, therefore, unclear what is meant that the gain is increased by the specific amount claimed because it is relevant to 35°. According to the Office, it appears that Applicant has attempted to claim a value relative to a "prior art" embodiment and that such an attempt is improper because it renders these claims indefinite. Applicant has herein amended claims 26 and 31, as well as claims 27, 28, 32, and 33 to specifically recite that the increase in gain is relative to the same antenna without the recited dielectric lens. This amendment should eliminate any potential indefiniteness in these claims.

The Prior Art Rejections

The Office further rejected claims 1, 8, 15, 18 and 35 under 35 U.S.C. § 102(b) as being anticipated by Japanese Document 3-10407 (hereinafter "JP '407"). The Office further rejected claims 2-5, 7, 9-14, 16, 19-23, 26, and 30-36 under 35 U.S.C. § 103(a) as being unpatentable over JP '407 in view of Nichols. The Office further rejected claims 6 and 17 under 35 U.S.C. § 103(a) as being unpatentable

over JP '407 in view of Nichols as applied to claims 2 and 16 and further in view of Feller. Finally, the Office rejected claims 24, 25 and 27-29 under 35 U.S.C. § 103(a) as unpatentable over JP '407 in view of Nichols as applied to the claims above and further in view of Brown.

Applicant has amended claims 1 and 15 to incorporate the limitations from claims 2 and 16, respectively, of a second ground plane between the dielectric substrate and the first ground plane for raising the patch and further increasing the radiation gain at angles less than 45°. In view of these amendments, the rejection of claims 1, 8, 15, and 18 as anticipated by JP '407 is now moot.

However, Applicant respectfully traverses the rejection of former claims 2 and 16 (the limitations of which are now incorporated into independent claims 1 and 15) as obvious over JP '407 in view of Nichols. Particularly, with respect to claims 2-7, 9-14,16 and 19-23, the Office asserted that JP '407 shows a microstrip antenna comprising a flat first conductive ground plane (unnumbered in the figures); a dielectric substrate 2 [sic, 1] disposed directly on the first ground plane; a patch 2 disposed on the substrate 1; a feed means for feeding the patch; and a dielectric lens 4 or 24 for encapsulating at least a portion of the patch to increase radiation gain at an angle as low as 35° to the patch.

Applicant respectfully traverses. JP '407 does not teach a first ground plane as recited in independent claims 1 and 15. Applicant has obtained an English translation of JP '407, a copy of which is attached hereto. There are no unnumbered elements in the figures of JP '407. The allegedly unnumbered "first conductive ground plane" in JP '407 in Figure 1 quite clearly is the dielectric lens 4. Specifically, note that dielectric lens 4 is cross-hatched in Figure 1 and extends around and underneath the substrate 1. Furthermore, Figure 2 which is a partial cutaway plan view of the antenna clearly actually labels the bottom layer as 4, i.e., part of the dielectric lens.

Accordingly, the Office's description of the primary reference is flawed. It does not disclose a ground plane.

In addition, the Office asserted that Nichols shows a second ground layer 36 between the dielectric substrate and the first ground plane "for raising the patch and further increasing the radiation gain at the low angles," and a space is created

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between the ground planes 36 and 62 for providing additional elements 16, 18, 20, 52 and 54. The Office asserted that it would have been obvious to the skilled artisan to employ the second ground layer and space for components of Nichols in the JP '407 antenna.

Applicant respectfully traverses. First and foremost, as noted above, the Office's analysis of the primary reference, JP '407, is fatally flawed. Particularly, the allegedly unlabeled layer below substrate 1 in Figure 1 of JP '407 is actually the labeled dielectric radome 4 and, therefore, is not the first ground plane. Therefore, the factual foundation upon which the combination rejection rests falls apart completely.

Wholly apart from and in addition to this fatal flaw in the rejection is the further flaw that there is no suggestion to combine JP '407 and Nichols.

A prima facie obviousness rejection must establish three things. As set forth in MPEP § 2143:

> First, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art to modify the reference or to combine the reference teachings. Second, there must be a reasonable expectation of success. Finally, the prior art reference (or references when combined) must teach or suggest all the claim limitations.

The Office has failed to present a prima facie obviousness case because it has not even attempted to offer any basis for concluding that there is a "suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art to modify the reference or to combine the reference teachings". Accordingly, the rejection fails the prima facie test for obviousness.

In fact, the Office has not proffered a motivation because there is none in the prior art. The question is why would one or ordinary skill in the related art having knowledge of JP '407 and Nichols be motivated to add the raised ground plane of Nichols to JP '407. The motivation for combining the second, raised ground plane with a lens in the present invention is to further improve low angle gain of the

antenna. Since JP '407 does not teach a second, raised ground plane (in fact, it does not even teach a first ground plane, as previously noted), it obviously cannot possibly provide such a suggestion of using a second, raised ground plane. Turning to Nichols, it certainly does not mention increasing low angle gain. Nichols has nothing to do with that. Accordingly, there does not appear to be any motivation provided in the references to make the combination. The question then is whether there is any other motivation provided in the prior art of record or in the general knowledge of those skilled in the art. Applicant cannot envision any. Certainly, the Office has not yet provided any. Accordingly, the proposed combination and obviousness rejection is *prima facie* unsustainable and should be withdrawn.

Hence, the independent claims 1 and 15 patentably distinguish over the prior art. Since all other claims depend from one of these claims, they too are patentable.

Even further, the dependent claims add even further patentably distinguishing recitations.

For instance, dependent claims 8 and 18 add the limitation that "the first ground plane is flat and that the dielectric substrate is disposed directly on the first ground plane." The Office asserted that this is taught in JP '407, Applicant respectfully traverses. Particularly, as discussed above, JP '407 does not disclose a ground plane and, therefore, obviously cannot disclose that the substrate is mounted directly on it. In fact, it would be impossible to place the substrate directly on a ground plane in JP '407 because the substrate 1 is mounted directly on the lens 4, as previously noted. Accordingly, dependent claims 8 and 18 further distinguish over the combination of JP '407 and Nichols.

Further, with respect to dependent claims 6 and 17, which add the limitation that "the second ground plane includes at least one slant portion, and a flat portion for disposing thereon the patch," the Office asserted that the Feller reference showed microstrip antenna 12 atop a first ground plane layer 23 and having a second, elevated ground plane 25 for raising the patch and further increasing the radiation gain at low angles (see column 1, lines 34-37), and having a "slant portion" (Fig. 1D). The Office asserted that it would have been obvious to employ the substrate 23 in base 13 of Feller in lieu of the flat base of the JP '407/Nichols

combination for the purpose of providing relatively low angle radiation in a GPS antenna, as suggested by the latter.

Applicant respectfully traverses. Feller does not teach a second elevated ground plane having a slant portion. Feller discloses a microstrip patch antenna having a patch 12 comprising portions 12a, 12b, 12c, 12d and 12e mounted on a substrate 13 having slant portions 15, 16, 17 and 18. *Col. 2, lines 57-61.* The bottom of the substrate has a ground plane 25. *Col. 3, lines 3-4 and col. 3, lines 11-13.* The substrate is mounted on a base 23 with a ground plane conductor 35 on its underside. *Col. 3, lines 7-13.* Referring to Figure 1A of Feller, note that the patch portion 12a is horizontal while patch portions 12b, 12c, 12d, and 12e extend over the slanted portions of the substrate. This design allegedly provides sensitivity to circularly polarized signals over a wide range of elevation and, in particular, at materially lower elevations than planar patch antennas. *Column 3, lines 29-32.* Thus, the increase in lower angle gain is provided by the patch portions 12b, 12c, 12d and 12e that are not co-planar with the horizontal portion 12a, but extend downwardly at an angle over the slant size of the substrate 13. This is a completely different design than the present invention.

Claims 6 and 17 recite that the <u>second ground plane</u> has slant portions. The "slant portion" shown in Figure 1D of Feller is not part of the ground plane 25, but is part of the substrate 13. Ground plane 25 is on the bottom surface (sometimes referred to as the "inner surface" in the specification of Feller) of the substrate 13. *See, column 2, lines 51-56 and column 2, lines 67 – column 3, line 6.* Thus, the two ground planes 23 and 25 in Feller referred to by the Office are co-planar and in contact with each other. Neither has a slant portion. Accordingly, contrary to the Office's assertions regarding claims 6 and 17, Feller does not disclose the limitations of an <u>elevated</u> ground plane <u>for raising the patch and further increasing the radiation gain at low angles</u> or <u>having a slant portion</u>. Hence, claims 6 and 17 further patentably distinguish over the prior art of record.

Finally, claims 26, 27, 28, 31, 32, and 33 recite specific values for radiation gain at specific angles relative to the same antenna without a lens. The Office has rejected these claims in view of the combination of JP '407 and Nichols asserting that, even though the references do not disclose these particular gains, specific

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magnitudes of gains at a particular angle are limitations strictly dependent upon the number of antenna elements, dielectric material of the lens and shaping of the lens and that such specifics are obvious to the skilled artisan because they are specifications set forth in a particular design model.

Applicant respectfully traverses. The Office appears to be asserting that, given the basic invention, achieving any particular gain at any particular angle is a matter of design specification. The Office is misinterpreting the import of these claim recitations. The import of these claim recitations is not merely the ability to achieve these gains at these specific angles, if desired. Rather, it is the discovery that they are particularly desirable specifications.

For instance, in connection with digital satellite radio in North America, such as that provided under the trade names XM™ and Sirius™, satellites are positioned at a fairly low angle to the horizon in order to cover a large geographic area with a small number of satellites (about 2 to 4). At least one of these satellite radio systems also uses a satellite close to the zenith. Accordingly, it is important to have excellent low angle gain while not substantially diminishing gain at zenith. This is achieved by the present invention, as described in the specification. Accordingly, antennas designed in accordance with the present invention that meet the limitations set forth in claims 26, 27, 28, 31 and 32 work particularly well for these satellite radio applications.

Hence, claims 26-28 and 30-32 do, in fact, further patentably distinguish over the prior art of record.

Request For Telephonic Interview

Applicant respectfully requests a telephonic interview with the Examiner after the Examiner has had an opportunity to review this Reply, but before issuing any subsequent Office Action. Particularly, due to delay in obtaining the translation of the JP '407 reference, Applicant was unable to review this matter sufficiently to prepare for an interview prior to the fourth month deadline for filing a Reply. Not wishing to incur the fee for a second month of extension and also because the issues at hand would be difficult to present and discuss without "seeing them in writing", Applicant files this Reply and seeks an interview subsequently. Any

courtesy in this regard that the Examiner can extend to Applicant would be greatly appreciated. Applicant's undersigned representative will call the Examiner by telephone within the coming weeks to attempt to schedule such an interview.

Conclusion

In view of the foregoing amendments and remarks, this application is now in condition for allowance. Applicant respectfully requests the Examiner to issue a Notice of Allowance at the earliest possible date. The Examiner is invited to contact Applicant's undersigned counsel by telephone call in order to further the prosecution of this case in any way.

Respectfully submitted,

Dated: ________

Theodore Naccarella
Registration No. 33,023
Synnestvedt & Lechner LLP
2600 Aramark Tower
1101 Market Street
Philadelphia, PA 19107
Telephone: (215) 923-4466
Facsimile: (215) 923-2189

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Japanese Kokai Patent Application No. Hei 3[1991]-10407

Job No.: 6511-95371 Ref.: WHITAKER DKT 17655

Translated from Japanese by the Ralph McElroy Translation Company
910 West Avenue, Austin, Texas 78701 USA

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JAPANESE PATENT OFFICE
PATENT JOURNAL (A)
KOKAI PATENT APPLICATION NO. HEI 3[1991]-10407

Int. Cl.[5]:	H 01 Q 19/06 1/42 21/06
Sequence Nos. for Office Use:	7402-5J 6751-5J
Filing No.:	Hei 1[1989]-144762
Filing Date:	June 7, 1989
Publication Date:	January 18, 1991
No. of Claims:	1 (Total of 4 pages)
Examination Request:	Not filed

RADOME FOR A PLANAR ANTENNA

Inventors:	Tatsuo Furukawa Nippondenso Co. Ltd. 1-1 Showa-cho, Kariya-shi, Aichi-ken
	Goro Inoue Nippondenso Co. Ltd. 1-1 Showa-cho, Kariya-shi, Aichi-ken
Applicant:	Nippondenso Co. Ltd. 1-1 Showa-cho, Kariya-shi, Aichi-ken
Agent:	Yusaku Goto, patent attorney

[There are no amendments to this patent.]

Claim

A type of radome for a planar antenna characterized by the fact that the radome is made of a dielectric that covers the upper side of the planar antenna, and the thickness of the radome is a function of position so that the radome acts as an electromagnetic wave lens.

Detailed explanation of the invention

Industrial application field

This invention pertains to a type of planar antenna.

Prior art

A planar antenna is usually covered with a radome to protect it from wind and snow. In the prior art the radome has been made of a material with a small dielectric constant that is formed to be as thin as possible in order to ensure that it does not affect the radiating characteristics of the electromagnetic waves.

Problems to be solved by the invention

However, although the aforementioned conventional radome for a planar antenna can protect the antenna from wind and snow, it cannot change the radiation directionality of the planar antenna. Consequently, the radiation directionality of the planar antenna depends on the structure of the antenna element itself, and it is difficult to set the radiation directionality as desired.

The purpose of this invention is to solve the aforementioned problems of the prior art by providing a type of radome for a planar antenna characterized by the fact that it allows changes in the radiation directionality setting of the planar antenna with a relatively high degree of freedom.

Means to solve the problem

In order to realize the aforementioned purpose, this invention provides a type of radome for a planar antenna characterized by the fact that the radome is made of a dielectric that covers the upper side of the planar antenna, and the thickness of the radome is a function of position so that the radome acts as an electromagnetic wave lens.

Operation

In the radome for a planar antenna with the aforementioned constitution, the radome itself forms a dielectric lens, so that the electromagnetic waves emitted from the planar antenna can be refracted at the radome interface, and the direction of the outgoing radiation can be changed.

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Application examples

In the following, this invention will be explained in more detail with reference to application examples illustrated by figures. Figure 1 is a longitudinal cross section illustrating Application Example 1 of this invention. Figure 2 is a plan view. Patch conductor (2) having a circular plate shape is arranged on nearly square printed substrate (1) to form planar antenna (3). Planar antenna (3) is covered with plate-shaped radome (4) that has an appropriate thickness. Radome (4) is made of a dielectric, and lower surface (4A) above patch conductor (2) has a hollow conical shape to form conical space (5). On the other hand, upper surface (4B) of radome (4) forms a flat plane. Consequently, the thickness of radome (4) above patch conductor (2) is a function of position, and it acts as an electromagnetic wave lens.

Consequently, electromagnetic waves (6) radiated from patch conductor (2) upward in the vertical direction are refracted at the interface between conical space (5) and radome lower surface (4A) and at the interface between radome upper surface (4B) and the external space, so that electromagnetic waves (7) propagate in an inclined direction while radiating outward. Assuming the specific dielectric constant of the dielectric that forms radome (4) to be ε_r, the refractive index n is expressed as $n = (\varepsilon_r)^{1/2}$. Figure 3 is a diagram illustrating the radiation directionality in the vertical plane. For a conventional planar antenna without refraction by the radome, lobe (9) extends upward in the vertical direction, as indicated by the broken line in the figure. On the other hand, in this application example lobe (8) is oriented obliquely with respect to vertical, as indicated by the solid line in the figure.

Figure 4 is a longitudinal cross section illustrating Application Example 2 of this invention. In this application example, not only is lower surface (24A) of radome (24) formed as a conical surface, but upper surface (24B) is also formed as a conical surface. However, the angle of upper conical surface (24B) with respect to vertical is different from that of lower conical surface (24A), so that radome (24) forms an electromagnetic wave lens in which its thickness is a function of position. In this application example, electromagnetic waves (26) radiated upward from patch conductor (2) are significantly refracted, and then travel nearly horizontally to be radiated as electromagnetic waves (27). As shown in Figure 5, it is possible to change the radiation directionality in the vertical plane such that lobe (28) becomes almost horizontal. Consequently, it is possible to form planar antenna (23) as a nondirectional antenna. Also, lobe (29) of a conventional planar antenna is shown as broken line in the figure.

Figure 6 is a longitudinal cross section illustrating Application Example 3. Figure 7 is a longitudinal cross section taken across A-A in Figure 6. In this application example, upper surface (34B) of radome (34) is formed as a horizontal surface. Lower surface (34A) is formed as a portion of a spherical surface. As shown in Figure 6, the central point of the spherical

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surface that forms lower surface (34A) deviates to the left of the center of patch conductor (2), and radome (34) is formed as a convex lens inclined with respect to the horizontal plane. In this application example, electromagnetic waves (36) radiated upward from patch conductor (2) are bent to the prescribed direction by convex-lens-shaped radome (34), and electromagnetic waves (37) are radiated in the prescribed direction. Consequently, as shown in Figure 8, lobe (38) is oriented in a prescribed direction corresponding to the direction of the convex lens comprising radome (34), and the electromagnetic waves are focused and radiated in the prescribed direction. Also, lobe (39) of a conventional planar antenna is shown as a broken line in the figure.

As explained above, radomes (4), (24), (34) are made of a dielectric and each forms an electromagnetic wave lens. By changing the lens shape, one can change the radiational characteristics of the planar antenna, which used to be unidirectional, to various directions, either nondirectional or inclined with the lobe focused sharply in the desired direction.

In the aforementioned application examples, it is also possible to adopt the following scheme: space (5), (25), or (35) is formed on patch conductor (2), and a dielectric with a dielectric constant different from that of radome (4), (24), or (34) is used to fill in said space (5), (25), or (35).

In addition, instead of forming the radome using a single type of dielectric, a combination of two or more types of dielectrics having different dielectric constants may also be used to form the electromagnetic wave lens.

Also, the planar antenna is not limited to a circular patch conductor antenna. Other shapes of planar antennas may also be adopted, such as patch-shaped, slot-shaped, line-shaped, etc. Also, the invention may be adopted for receiving antennas.

Effects of the invention

In this invention, the radome with the aforementioned constitution forms an electromagnetic wave lens. Consequently, instead of conventional planar antennas that are unidirectional, antennas can be formed that are either nondirectional or that have various directionalities, as desired.

Brief description of the figures

The figures illustrate application examples of this invention. Figure 1 is a longitudinal cross section illustrating Application Example 1 of this invention. Figure 2 is a plan view. Figure 3 is a diagram illustrating the directionality characteristics, showing radiation directionality in the vertical plane. Figure 4 is a longitudinal cross section illustrating Application Example 2. Figure 5 is a diagram illustrating the directionality characteristics. Figure 6 is a longitudinal cross section illustrating Application Example 3. Figure 7 is a longitudinal cross

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section taken across A-A in Figure 6. Figure 8 is a diagram illustrating the directionality characteristics.

1	Printed substrate
2	Patch conductor
3, 23, 33	Planar antenna
4, 24, 34	Radome
4A	Lower surface (conical surface)
4B	Upper surface
8	Lobe

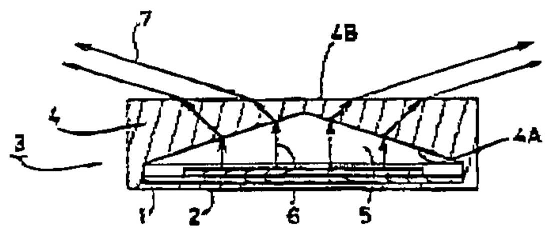

Figure 1

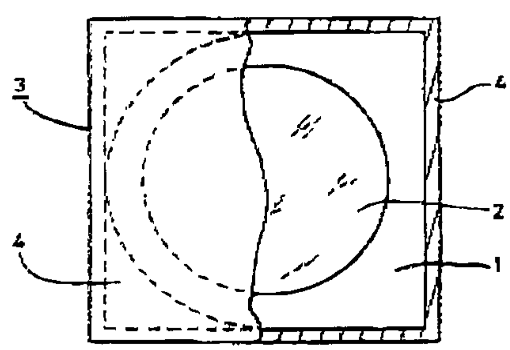

Figure 2

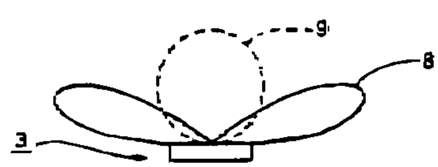

Figure 3

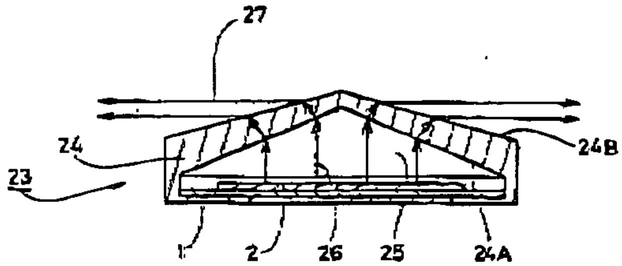

Figure 4

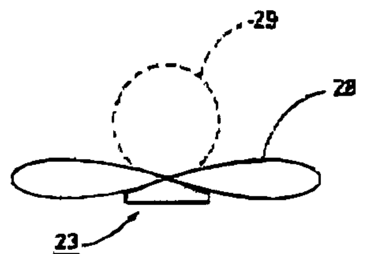

Figure 5

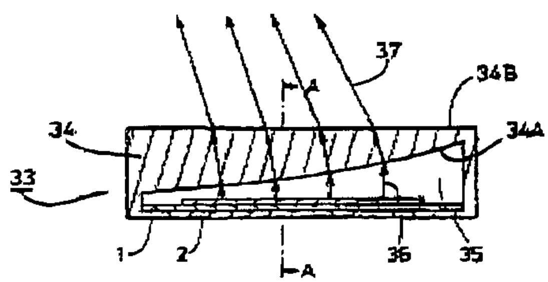

Figure 6

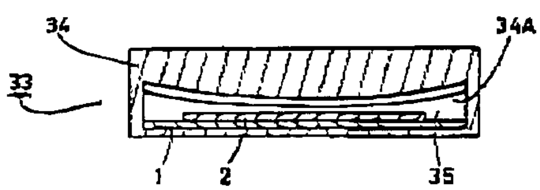

Figure 7

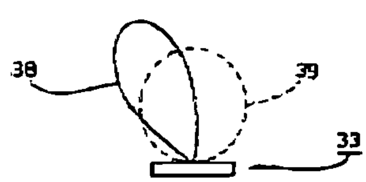

Figure 8